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PROGRAM OF THE

CHICAGO MEETING

AT

THE UNIVERSITY OF CHICAGO

CHICAGO, ILLINOIS

November 22–23,.1940

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NOVEMBER 7, 1940 Vol. 15, No. 5

BULLETIN

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AMERICAN PHYSICAL SOCIETY

CHICAGO MEETING, NOVEMBER 22–23, 1940

THE 237th regular meeting of the American Physical Society will be held at Chicago, Illinois, on Friday and Saturday, November 22 and 23, 1940. All sessions for the reading of contributed papers will be held at the University of Chicago in Eckhart Hall and the Ryerson Physical Laboratory.

Dinner. On Friday evening, November 22, there will be a dinner. In view of the 50th Anniversary Celebration, the University of Chicago has made available for the Society the dining hall in Judson Court, 1005 East Sixtieth Street (corner of Ellis Avenue). From 5:30 to 6:30 there will be a reception in the lounge of Judson Court (southwest corner). Dinner will be served promptly at 6:30. Tickets will be $1.50 each and should be obtained before Friday noon.

Headquarters. The Windermere Hotel, 1642 East 56 Street, near the campus, has been selected as hotel headquarters. Reservations should be made directly with the hotel. The rates are as follows: single rooms, $3.50; double rooms, $5.00.

Railroad Rates. Members should consult with their local passenger agents before purchasing tickets.

Annual Meeting. The preliminary arrangements for the Philadelphia program include a joint session on Friday afternoon, December 27, with Section B of the American Association for the Advancement of Science and the American Association of Physics Teachers, at which time addresses will be delivered by the Retiring Vice President of Section B, Ernest O. Lawrence, and by the President of the American Physical Society, John Zeleny. Arrangements are also being made for a joint session with Section E—Geology—of the American Association for the Advancement of Science.

GENERAL RULES RELATING TO PAPERS

Only those titles of papers shall be listed on the preliminary program of a meeting of the Society for which abstracts ready for publication are in the hands of the Secretary.

On December 28, 1936, the Society voted that:

> No papers may be accepted for presentation at any meeting of the Society subsequent to the closing date stated in the printed call for that meeting.

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program. (A paper presented by two or more authors is assigned to the first named author.)

All supplementary papers will be grouped according to subject matter and will be called for at their appropriate sessions only, these sessions to be designated on the program. The presiding officer may assign a reduced time to these papers or may in his discretion call for them to be read by title only.

Except by special vote of the Society, the maximum allowance of time for the presentation of a paper shall be ten minutes. The presiding officer shall enforce this rule.

Titles and abstracts of the papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction the abstracts will be published in an early number of the *Physical Review*. Authors should send corrections to the Publications

Manager, The American Institute of Physics Incorporated, 175 Fifth Avenue, New York, N. Y.

Other meetings for the current season are as follows:

238. December 20–21, 1940. Pasadena, California. Pacific Coast Meeting.
239. December 26–28, 1940. Annual Meeting. Philadelphia, Pennsylvania.
240. February 21–22, 1941. Cambridge, Massachusetts.
241. May 1–3, 1941. Washington, D. C.
242. June 20–21, 1941. Providence, Rhode Island.

W. L. SEVERINGHAUS, *Secretary*
Columbia University, New York, N. Y.

November 7, 1940.

CALENDAR

Friday morning, November 22

10:00 o'clock: Eckhart 133: Papers 1–11. See pages 5–7.

10:15 o'clock: Eckhart 316: Meeting of the Council.

Friday afternoon, November 22

2:00 o'clock: Eckhart 133: Papers 12–21. See pages 7–9.

2:00 o'clock: Ryerson 32: Papers 22–30. See pages 9–11.

Friday evening, November 22

5:30 o'clock: Judson Court: Reception.

6:30 o'clock: Judson Court: Joint dinner with the Chicago Physics Club.

Saturday morning, November 23

10:00 o'clock: Eckhart 133: Papers 31–40. See pages 11–13.

10:00 o'clock: Ryerson 32: Papers 41–49. See pages 13–15.

PROGRAM

FRIDAY MORNING AT 10:00 O'CLOCK

Eckhart 133

1. Low Terms in Co VII and Ni VIII. E. E. ANDERSON AND J. E. MACK, *University of Wisconsin.*—Bowen's work on the low levels in the scandium-like isoelectronic sequence up to Fe VI has been supplemented by the identification of the levels $3d^3\ {}^4FP\ {}^2GH$ (also Bowen's "A") and $3d^24p\ ({}^3F)\ {}^{4,2}GFD\ ({}^3P)\ {}^4DPS\ ({}^1G)\ {}^2HG$ in Co VII and Ni VIII. (There is doubt as to the reality of the proposed Ni VIII $d^3\ {}^2H_{5\frac{1}{2}}$, $d^2p\ ({}^3F)\ {}^2D\ ({}^3P)\ {}^4P\ ({}^1G)\ {}^2H_{5\frac{1}{2}}$.) The identification of appreciably more lines, especially intercombinations, here than in lower spectra in the sequence, may be attributed to the gradual change in coupling as well as the high excitation from our 2 μf, 60,000-volt sparks. Work is progressing on the comparison of the separations in $3d^3$ with Marvin's equations (for Co I d^7s^2, including ls interaction). Heretofore, among isoelectronic sequences in this neighborhood, no configuration $3d^{x-1}4p$ has been identified beyond stage VI. Undoubtedly the correct explanation of this limitation is Bowen's, that $3p^53d^{x+1}$ is expected to cross, and therefore disturb, $3d^{x-1}4p$ at about that stage. (At present a level in this neighborhood can hardly be expected to be found unless it can be predicted with fair accuracy.) Although some small irregularities remain to be explained, the general smoothness of the curves $\nu(Z)$ throughout this sequence indicates that $3p^53d^4$ is probably still well above $3d^24p$ in Co VIII.

2. On the Spectrum of Hg II. S. MROZOWSKI, *University of Chicago* (*Introduced by R. S. Mulliken*).—The previously found[1] complex structures of many lines in the singly ionized mercury spectrum have been critically examined and the isotope shifts in 49 energy levels and the hyperfine structure splittings in 10 of them have been roughly determined. The isotope shifts and hyperfine splittings are very small for levels of the configurations $5d^{10}nx$ (excluding the ground state formerly studied[1]), and quite considerable for levels of the type $5d^96snx$. In the latter case shifts of about 0.3 cm^{-1} (between consecutive even isotopes) and hyperfine splittings amounting to from 0.4 to 1.3 cm^{-1} have been found. A few perturbations are present in both sets of levels. The analysis shows further the necessity of rejecting the existing classification of some lines. Nearly a half of the lines studied are not yet classified, and serious difficulties are encountered in the classification of a part of them.

[1] S. Mrozowski, Phys. Rev. **57**, 207 (1940).

3. The Zeeman Effect of Xenon. E. H. HURLBURT, D. W. BOWMAN, AND J. B. GREEN, *Ohio State University.*—Measurements of about 125 lines in the spectrum of Xe I yield g-values for the only two completely known configurations of Xe I. The results are partially in disagreement with those published by Lörinczi.[1] For a number of configurations, partial g-sums indicate that the J of the core is a "good" quantum number, while the extra electron represents an interesting case of intermediate coupling. This is especially true for the p^5f configurations.

[1] Lörinczi, Diss. Budapest, 1937.

4. The Paschen-Back Effect. VIII. Configuration Interaction. J. B. GREEN, D. W. BOWMAN AND E. H. HURLBURT, *Ohio State University.*—The spectrum of krypton furnishes a very fine example of the effect of configuration interaction. The levels $3s_5$ and $4d_2$, belonging to configurations of the same parity, are less than 1 cm^{-1} apart, and the Zeeman patterns of lines arising from them show large perturbations, both as regards positions and relative intensities of the components. A semi-empirical theory is discussed which leads to excellent agreement with experiment.

5. A Rotational Analysis of Some CS_2 Bands in the Near Ultraviolet. LEONARD N. LIEBERMANN, *University of Chicago* (*Introduced by R. S. Mulliken*).—The rotational structure of six bands in the region 3450A–3700A has been analyzed.[1] Alternate J values are missing as is expected from the zero spin of the sulphur nuclei. The band lines follow the formula: $\nu = A + Bm + Cm^2 - sm^4$. The m^4 term in this formula is not related to the centrifugal expansion, but to the triangular shape of the molecule in its excited electronic state. The value of s as a function of the apex angle can be derived from asymmetrical top theory and leads to 120° for the apex angle of CS_2 in its excited state. This value is confirmed by the results of an analysis of a band with a Q branch. An equation has been derived relating the separation of the upper state rotational levels of this band to the apex angle. Two bands show a perturbation which is attributed to their common upper Σ state being perturbed by a neighboring Π state. A partial vibrational analysis could be made because some bands have states in common. The frequency for the bending vibration ν_2 for the lower state is 401 cm^{-1}, while that for the deformation vibration ν_2 in the upper state is probably 275 cm^{-1}.

[1] A preliminary report has been published. See Phys. Rev. **58**, 183 (1940).

6. Explanation of the Rotational Structure of the λ3800 Band System of SO_2. N. METROPOLIS, *University of Chicago.*—Photographs of the rotational structure of the absorption bands of SO_2, taken in first and second order with our 30-ft. grating spectrograph, show a remarkable shading to both sides. This is true of about twelve individual bands, whose vibrational analysis has been reported.[1] Exposures taken at various temperatures have intensity

distributions corresponding to a band origin approximately at the center of the band. The rotational structure of the absorption bands exhibits a coarse structure degraded toward higher frequencies. These transitions are associated with the component of angular momentum along the symmetry axis and are called the K structure. A much finer J structure extends and fades out toward lower frequencies. These characteristics indicate that $C_K' > C_K''$ and $B_J' < B_J''$, where B and C are coefficients of the K and J structure, respectively. In terms of dimensional changes in the transition, it means that an increase of the apex angle, $\alpha' > \alpha''$, is a necessary condition and is here more significant than a change of the bond distances. This result is in agreement with the intensity distribution of the vibrational structure. A general treatment of the dimensional changes and their effect on the patterns of the rotational bands of polyatomic molecules has been carried through.

[1] N. Metropolis and H. Beutler, Phys. Rev. **57**, 1078 (1940).

7. Raman Spectra of Some Ethers Containing One or More Phenyl Groups. FORREST F. CLEVELAND AND M. J. MURRAY, *Illinois Institute of Technology.*—Raman frequencies, estimated intensities and depolarization factors have been obtained for n-propylphenyl, n-butylphenyl, ethylbenzyl, n-butylbenzyl and dibenzyl ethers by use of a spectrograph having a linear dispersion of 33 A/mm at 4500A. Characteristic monosubstituted benzene frequencies whose values were constant in the five ethers are 618(5)0.8, 1001(10)0.1, 1029(7)0.3, 1156(4)0.8, 1176(4)0.8, 1588 and 1604(6)0.7, 3058(9)0.3. In the 3000 cm^{-1} region, the lines 3009(1) and 3164(1/2), as well as 3058(9)0.3, are attributed to vibrations involving the phenyl group hydrogens. The polarized frequency near 2860 and the depolarized frequency near 2960 seem to correspond to symmetrical and unsymmetrical vibrations of the $-CH_2-$ group, while the polarized 2930 line probably corresponds to an inner frequency of the $-CH_3$ group. A frequency 2911(6)0.6 was observed for the three ethers containing the propyl and butyl groups, but not for the other two. A weak line at 3204 in the benzyl ethers may correspond to the overtone of the 1600 frequency. The ether group ($R-O-R'$) frequencies are possibly the ones near 1125, 900 and 440 cm^{-1}.

8. Use of the Radioactive Properties of Thorium for a Quantitative Study of Phagocytosis. F. A. MAXFIELD AND O. A. MORTENSEN, *University of Wisconsin.*—Use has been made of the radioactive properties of colloidal thorium dioxide, intravenously injected into rabbits, to study the functional capacity of the reticulo-endothelial cells for phagocytosis. A mathematical analysis of the problem is presented which indicates that when the system is not overloaded, the foreign material should be removed from the blood according to the relation

$$n = n_0 e^{-at} + (b/2\alpha) n_0 e^{-bt}.$$

Here $a \gg b$ and n is the number of particles remaining in the blood at any time, t. Experiments on 13 rabbits substantiate this prediction. With a standard injection of 1 cc of colloidal thorium dioxide per kilogram of body weight, n decreases according to three distinct exponential relations. The system is apparently overloaded initially, but after n decreases to about one-sixth its initial value (at $t=0$), the fraction of the amount of material present that is removed in unit time increases and the rest of the curve follows the predicted relation. The fact that the system is initially overloaded was checked by the use of smaller amounts of thorium. In all cases more than 99 percent of the thorium was removed from the blood stream within 6 or 8 hours after the injection. The technique reported here should serve as a basis for testing many theories of phagocytosis now largely based on deduction.

9. Some Rules Concerning Isobaric Radioactive Nuclei. ARTHUR E. HAAS, *University of Notre Dame.*—Isobaric pairs of artificially produced β^--emitters obey the rule that the nucleus with odd charge number has the greater half-life. Isobaric pairs of unstable nuclei of which one is a β^-- the other a β^+-emitter, follow in general the rule that the positron-emitter has the shorter half-value period. These two rules can be explained on ground of the well-known fact that the exchange force between two neutrons is, under otherwise equal conditions, stronger than that between two protons. For light β^+-emitters the half-life is often between $\frac{1}{3}$ and $\frac{2}{3}$ that of the isobaric β^--emitter. In the case of an isobaric β^-, β^--pair the corresponding stable isobaric nucleus has always a higher atomic number than the pair. In the case of an isobaric β^-, β^+-pair, however, the stable isobaric nucleus has an atomic number between those of the pair. The last two rules may be derived from Gamow's stability diagram.

10. A Magnetic α-Particle Spectrograph. ROY RINGO, *University of Chicago* (*Introduced by A. J. Dempster*).—A 60° deflection magnetic spectrograph, which will measure α-particles of energies from 2 to 20 Mev, has been constructed. It is readily movable and the position of the source is 42 cm from the magnetic field. These two features make it suitable for use with apparatus for artificial disintegration. The particles are detected on photographic plates where the individual tracks are observed microscopically. This method permits the use of exposures of indefinite length. The instrument was calibrated by obtaining its dispersion with α-particle groups of known energy from natural radioactive sources. The energy of the main group of protoactinium α-particles was found to be 5.053 ± 0.007 Mev by comparison with polonium α-particles taken as 5.303 Mev.[1] In all the α-particle spectra investigated large numbers of particles with energies below the main group are found. There is apparently a continuous distribution of these energies below that of the main group; as many as 10 percent of the particles have energies 5 percent or more below. The explanation of this retardation as absorption in the source is made doubtful by the fact that a 5 percent energy loss is equivalent to that in 2 mm of air, and on the thin sources used the amount of material is insufficient to account for this even considering clumping. Scattering of the particles is not a possible explanation as that should

cause some particles to appear on the high energy side of the main group and none are found there.

[1] Rutherford, Wynn-Williams, Bowden, and Lewis, Proc. Roy. Soc. **A139**, 617 (1933).

11. Voltage Distribution on a Multi-Section Accelerating Tube. L. J. HAWORTH, J. H. MANLEY, AND E. A. LUEBKE, *University of Illinois.*—Difficulty in maintaining a uniform potential distribution on a multi-section accelerating tube was encountered when using the large ion currents from a modified Zinn type source. Current measurements indicated the flow of large numbers of secondary electrons between the accelerating electrodes. Introduction of external leakage currents so large as to overload the voltage supply did not appreciably affect the potential distribution. The difficulty was overcome by an arrangement of diaphragms each of which was connected to its surrounding electrode through a resistance of 10^5 ohms. Small ion currents to and electron currents from the diaphragms thus provide sufficient potential difference to prevent the escape of all secondaries except the relatively small number possessing high initial energies.

FRIDAY AFTERNOON AT 2:00 O'CLOCK

Eckhart 133

12. The Distribution in Angle of the Alpha-Particles from Boron Bombarded with Protons. JAMES A. JACOBS AND WILLIAM L. WHITSON, *State University of Iowa.*—The distribution in angle of the alpha-particles from boron bombarded with protons has been investigated at the resonance energy (160 Kev) and just above resonance (200 Kev). The target consisted of boron trifluoride gas at a pressure of 0.3 mm of mercury. Range-number curves were obtained at five different angles for both the above energies. These curves, when corrected for the variation of range with angle, show complete spherical symmetry for both the continuous and the homogeneous groups of alpha particles. The apparent asymmetry found for this reaction by Haxby, Allen, and Williams[1] and by Neuert[2] may be due to the difficulties in applying range corrections for alpha particles produced in a thick target.

[1] Haxby, Allen, Williams, Phys. Rev. **55**, 140 (1939).
[2] Neuert, Physik. Zeits. **38**, 122, 618 (1937); Ann. der Physik **36**, 437 (1939).

13. Interaction between Two Alpha-Particles and the Properties of Be^8. JOHN A. WHEELER, *Princeton University.*—Deviations from the scattering to be expected on the basis of an inverse square law of force between alpha particles receive a satisfactory interpretation in terms of the influence on particles of zero, two and four units of angular momentum of a specific nuclear interaction having a range less than 9×10^{-13} cm. The semi-stable excited state of the compound nucleus Be^8 formed in certain disintegration experiments is found from the scattering analysis to have an energy of about 3 Mev, a mean life of 0.8×10^{-21} sec. and *zero* angular momentum. For the normal state of Be^8 various values of the energy of disintegration have been assumed and for each has been calculated the number of coincidences to be expected in the experiments of Laaff and Fink. Reasonable agreement is obtained with an energy release of 125 kev, corresponding to a half-life of the order of 10^{-15} to 10^{-17} sec. It remains difficult to understand an apparent selection rule in the formation of Be^8 from the reaction of B^{11} with protons.

14. Electrostatic Deflection Studies of Alpha-Particles; the Alphas from $Li^6(p,\alpha)He^3$. SAMUEL K. ALLISON, LEONARD C. MILLER, LESTER S. SKAGGS, AND NICHOLAS M. SMITH, JR., *University of Chicago.*—A technique is described for studying nuclear reactions in which short range alpha-particles are produced with a yield that is too small for the direct application of the electrostatic deflector. In preliminary experiments a strong polonium source is used to supply alpha-particles to the deflector, and a group of these alphas, homogeneous in energy, passes through the deflector and enters a variable pressure absorption cell and ionization chamber. Cut-off pressures determined for various alpha-particle energies result in a calibrated cell which can then be used to determine the alpha-particle energies in nuclear disintegrations. Application of this method to $Li^6(p,\alpha)He^3$ results in a Q value of 3.94 ± 0.08 Mev. The calibration, extending in alpha-particle energy from 1 to 1.8 Mev, is also used to determine the slope of the range energy curve. The average value of the slope found for this region is 200 kv per mm range.

15. The Absolute Number of Quanta from the Bombardment of Fluorine with Protons. J. A. VAN ALLEN* AND NICHOLAS M. SMITH, JR.,* *Department of Terrestrial Magnetism, Carnegie Institution of Washington.*—From the experiments of Lauritsen and associates and of Burcham and associates, it seems very probable that the 6.3-Mev quanta from the proton bombardment of fluorine are associated in one-to-one correspondence with the short range alpha-particles. This correspondence makes possible the establishment of the gamma-ray intensity by measuring the alpha-particle yield. Using a specially designed variable pressure absorption-cell ionization-chamber, to facilitate clear distinction between the short range alpha-particles and the scattered protons, we have determined the angular distribution and total yield of the alpha-particles at the lowest resonance (330 kv). The determinations were based on plateaus appearing in curves of counting rate as a function of (1) cell pressure, (2) counter bias, and (3) bombarding

voltage at angles of 60°, 90°, 120°, and 150° with respect to the proton beam. Our results show that: (a) To within two percent the angular distribution of the alpha-particles is spherically symmetric; and (b) The yield over 4π steradians is $8.9\pm0.5\times10^4$ alpha-particles per microcoulomb of protons bombarding a thick crystal of CaF_2. The absolute number of quanta from the reaction is presumably the same to the same accuracy. We find the angular distribution of the gamma-rays to be spherically symmetric to within the experimental error of five percent. Knowledge of the intensity of the fluorine source greatly enhances its value in photo-nuclear and other experiments.

* Carnegie Institution Fellow.

16. Short-Lived Radioactivities of $_{14}Si^{27}$, $_{16}S^{31}$, $_{18}A^{35}$, and $_{21}Sc^{41}$. L. D. P. KING AND D. R. ELLIOTT, *Purdue University.*—Radioactive elements belonging to the series characterized by $Z-N=1$ are of theoretical importance for nuclear structure determinations.[1] In an attempt to extend this series the following new reactions have been observed:

	HALF-LIFE
$_{12}Mg^{24}(\alpha,n)_{14}Si^{27}$ [2]	4.92 sec.
$_{14}Si^{28}$ $(\alpha,n)_{16}S^{31}$	3.18 sec.
$_{16}S^{32}$ $(\alpha,n)_{18}A^{35}$	1.91 sec.
$_{20}Ca^{40}$ $(d,n)_{21}Sc^{41}$	.87 sec.

The first three reactions were produced by 16-Mev alpha-particles, the final one by 8-Mev deuterons. The bombardments were performed outside of the cyclotron which reduced the bombarding energy by 0.6 mil of aluminum. Measurements of half-lives were made by means of a multiple scale Geiger counter circuit. The dial readings of the mechanical counter were photographically recorded at regular time intervals of one-half or one second. Bombarding times varied from a fraction of a second to three seconds using beam intensities of about 0.05 microampere of deuterons and alpha-particles. All the activities obtained showed an exponential decay over at least three half-lives. Any background or weak long periods were eliminated by subtraction.

[1] E. Wigner, Phys. Rev. **56**, 519 (1939).
[2] G. Kuerti and S. N. Van Voorhis, Phys. Rev. **56**, 614 (1939); Barkas, Creutz, Delsasso, Sutton and White, Phys. Rev. **50**, 38 (1940).

17. Absorption Cross Sections for Slow Neutrons. M. GOLDHABER AND R. D. O'NEAL, *University of Illinois.*—Cross sections for radiative capture of C neutrons which are $<10^{-24}$ cm^2 are not known for many elements. In those cases where the isotope produced by slow neutron capture is radioactive the capture cross sections can be determined by comparing the induced activity with that of an element of known cross section for C neutron capture. Using Mn ($\sigma_c=9.4\times10^{-24}$ cm^2) [1] as a standard we have measured a number of cross sections in this way with the help of a 100 mg Ra-α-Be source. The results are tabulated below. (T=half lifetime of radioactive isotope, σ_{eff}=effective cross section for average atom, σ_c=capture cross section corrected for abundance of isotope.)

ELEMENT	T	σ_{eff} IN 10^{-24} CM^2	ABSORBING ISOTOPE	σ_c IN 10^{-24} CM^2
7 N	8 sec.	<0.0008	N^{15*}	<0.2
9 F	12 sec.	<0.05	F^{19}	<0.05
11 Na	14.8 hr.	0.4	Na^{23}	0.4
12 Mg	10.2 min.	0.03	Mg^{26}	0.3
13 Al	2.4 min.	0.2	Al^{27}	0.2
14 Si	170 min.	<0.03	Si^{30}	<0.7
15 P	14.3 day	0.3	P^{31}	0.3
17 Cl	37 min.	0.07	Cl^{37}	0.3
19 K	12.4 hr.	<0.05	K^{41}	<0.7
20 Ca	2.5 hr.	<0.01	Ca^{48}	<5
28 Ni	2.6 hr.	<0.03	Ni^{62}	<0.8
29 Cu	5 min.	0.8	Cu^{65}	2.4
51 Sb	2.8 day	2	Sb^{121}	3.6
	60 day	1	Sb^{122}	2.3
81 Tl	4.2 min.	<1	Tl^{203}	<3.3
83 Bi	5 day	<0.1	Bi^{209}	<0.1

[1] Lapointe and Rasetti, Phys. Rev. **58**, 554 (1940).

18. Neutron Capture Cross Sections of F^{19}, Tl^{203}, and N^{15}. J. H. MANLEY, L. J. HAWORTH, AND E. A. LUEBKE, *University of Illinois.*—With the use of the absorbers used by Goldhaber and O'Neal, neutron capture cross sections of F^{19}, Tl^{203}, and N^{15} have been measured with neutrons produced by the D–D reaction in the Illinois linear accelerator. On the basis of a cross section for Al^{27} of 0.2×10^{-24} cm^2 as found by Goldhaber and O'Neal (preceding abstract) the values found are in 10^{-24} cm^2: $\sigma(F^{19})=0.01$, $\sigma(Tl^{203})=1.7$, $\sigma(N^{15})<0.01$.

19. On the Activation of Chlorine by Slow Neutrons. R. D. O'NEAL, *University of Illinois.*—An attempt was made to determine the half-life of Cl^{36} (reported by Grahame and Walke as >1 year) [1] by a method similar to that described recently for H^3.[2] For this purpose CCl_4 was irradiated inside paraffin with neutrons from a 100 mg Ra-α-Be source for 9 months. The activated chlorine was separated by a Szilard-Chalmers separation. The 37 minute Cl^{38} was found to be separated with an efficiency of nearly 100 percent. However, no long-lived chlorine could be detected in the sample. If one assumes the separations to be equally efficient for the long as for the short-lived chlorine it follows that the half-life of $Cl^{36}>1000$ years. When chlorine is bombarded with fast neutrons the well-known 88-day activity of sulphur is produced. This has been ascribed to S^{35}. As the reaction $Cl^{35}(n,p)S^{35}$ would have a positive energy release of about 650 kev it is conceivable that it takes place also with slow neutrons. Previous attempts to find heavy particles emitted from chlorine bombarded with slow neutrons have been negative.[3] However, cross sections of $<10^{-24}$ cm^2 would probably have escaped detection in these experiments. Sulphur separated from the CCl_4 sample showed no activity which implies that the cross section of the reaction $Cl^{35}(n,p)S^{35}$ <1/1000 of the cross section of the reaction $Cl^{35}(n,\gamma)Cl^{36}$.[4] This result together with that of Sagane[5] who failed to obtain the 88-day sulphur isotope by bombarding sulphur with deuterons makes it appear likely that this isotope is S^{37} and not S^{35}.

[1] See J. J. Livingood and G. T. Seaborg, Rev. Mod. Phys. **12**, 30 (1940).
[2] R. D. O'Neal and M. Goldhaber, Phys. Rev. **58**, 574 (1940).
[3] J. Chadwick and M. Goldhaber, Proc. Camb. Phil. Soc. **31**, 612 (1935).
[4] C. Lapointe and F. Rasetti, Phys. Rev. **58**, 554 (1940).
[5] R. Sagane, Phys. Rev. **50**, 1141 (1936).

20. Energy Distribution of Continuous X-Rays from Nuclear Excitation. G. B. COLLINS AND B. WALDMAN, *University of Notre Dame.*—The nuclear activity of indium induced by x-rays has been used to measure the energy distribution of these x-rays near their threshold. This is possible since it is known that for energies below 1.5 Mev indium is excited only by a narrow band of x-rays at 1.1 Mev.[1] Foils of indium were excited by irradiating them with x-rays produced in a gold foil (1.2×10^{-3} cm) by monochromatic electrons with energies above 1.1 Mev. By varying the energy of these electrons, the relative intensity of the x-ray spectra at different distances from the short wave limit was determined by the activity induced in the indium foils. The intensity of the x-rays was found to have a finite value at the short wave-length limit, and near the threshold to be approximately independent of the wave-length. This is in agreement with theory (see next abstract). The over-all cross section for the excitation of indium and lead by 1.2-Mev electrons, which contains, as factors, the intensity of the x-rays near the short wave limit, the radiation width of the activation level and the branching ratio, has been estimated to be about 10^{-32} cm² for both elements.

[1] Phys. Rev. **55**, 1129 (1939).

21. On the Excitation of Nuclei by X-Rays. EUGENE GUTH, *University of Notre Dame.*—It is shown how values of the radiation widths of activation levels may be deduced from experimental cross sections for nuclear excitations by x-rays. In interpreting the experimental data (see preceding abstract), which were obtained using electrons for the production of the x-rays, theoretical formulae were introduced for: (a) the intensity of x-rays near the short wave limit; (b) the dependency upon the energy of the radiation multipole matrix elements. The intensity of the x-rays was found to have a finite value at the short wave limit and near the short wave limit to be approximately independent of the wave-length, or of the energy of the incident electrons. Herefrom an excitation curve with many flat plateaus follows, each plateau indicating another level. The dependency of the multipole matrix elements upon the energy gives the ratio of the transition probabilities from the activation to the ground and the metastable level. From the experimental cross sections for In^{115} and Pb, radiation widths of about ten millivolts were obtained. These values are of the same order of magnitude as the radiation widths of the excited levels of RaC′ and ThC′.

FRIDAY AFTERNOON AT 2:00 O'CLOCK

Ryerson 32

Paper No. 27 will be read by title.

22. The Structure of Liquid Nitromethane. G. C. DANIELSON AND K. LARK-HOROVITZ, *Purdue University.*—From Fourier analyses of the x-ray diffraction pattern of liquid nitromethane, different distribution curves in the liquid have been determined. The electron and atomic distribution curves show that the first and second atomic neighbors are fixed at the distances of the atoms in the molecule which agree with the ones determined from the electron diffraction pattern of the gas. As indicated by the distribution curve, their distances are, therefore, not subject to statistical fluctuations. The number of first neighbors is 1.6 at 1.33A and the number of second neighbors is 1.6 at 2.40A which agree with electron diffraction determinations. Further concentrations of atoms are found at 3.48A, 4.28A, and at 5.26A. The molecular distribution curve gives 1.9 first neighbors at 3.48A, 2.7 second neighbors at 4.28A, and 3.6 third neighbors at 5.26A. The analyses of molecular distribution curves show that the flat shaped molecules have their first neighbors in parallel arrangement and not at random orientation.

23. Electron Distribution in Metallic Lithium as Determined from X-Ray Diffraction Measurements. R. L. GRIFFITH AND P. M. HARRIS, *Ohio State University.*—The intensity of the crystalline scattering of Cu $K\alpha$ x-rays from metallic lithium powder was determined at 300°, 195° and 90°K, respectively, using an ionization spectrometer. Values of the Debye θ were calculated from the intensity measurements. The results are not in agreement with published calorimetric measurements which are also anomalous. Values of the atomic form factor appear to be much smaller for metallic lithium than for the ion in lithium fluoride, indicating a more diffuse electron distribution in the metal. A three-dimensional Fourier series for the electron density has been evaluated in certain directions. These results show a maximum in electron density midway between two atoms along the edge of the cubic unit cell. This maximum is much more pronounced at 90°K than at room temperature. A corresponding separation of the crystal structure factors into two groups (one group for all indices even, one for two odd and one even) is apparent. These results may be accounted for by a maximum in the electron density along the three coordinate axes at distances $\pm a_0/2$ from the atom. Presumably these data may be interpreted as evidence of a metallic bond. Radial charge distribution curves were also obtained for the lithium and hydrogen in lithium hydride.

24. A Method for Obtaining Powders of Uniform Sodium Chloride Crystals in Various Size Ranges, and the Effect of Size Upon the Intensity of X-Ray Reflection. FITZ-HUGH MARSHALL, *University of Chicago* (*Introduced by S. K. Allison*).—I. A technique is presented for precipitating powders of sodium chloride crystals, uniform in size and cubical in shape, in various size ranges from 1 to 70 microns, above which the range could be extended by screening. The crystals are prepared by precipitation with absolute ethyl alcohol from a saturated solution of sodium chloride in water, but varying excess quantities of water are added to either of the solutions before combining them. Control of size range, and of crystal uniformity within a size range, is accomplished by careful attention to certain primary variables in the precipitation process, each of which produces marked changes in the character of the powder obtained. These are discussed and a simplified procedure is presented for producing any desired size. II. This technique was developed to make possible a study of the variation of intensity of x-ray lines reflected from such size-graded powders. The 200-reflection of Cu $K\alpha$ radiation has been investigated, and a curve is shown for the variation of intensity with crystal size. The intensity decreases slightly with increase of crystal size, according to a curve which indicates that the crystals are imperfect but are more perfect than large single crystals.

25. The Measurement of the Intensity of X-Rays of Wave-Length 0.14A to 1.0A by Means of an Electron Multiplier Tube. JAMES S. ALLEN, *Kansas State College*.—An electron multiplier tube has been designed for the measurement of very weak x-ray intensities. Ten of the twelve electrodes in the tube are covered with a thin layer of beryllium. Multiplication occurs at these surfaces. The beam of x-rays enters the tube through a thin bubble window and ejects photoelectrons from the first electrode. The sensitive surface is composed of a thin tantalum foil. This metal was chosen because of its high atomic number and also because of the fact that it acts as a getter. The efficiency of the tube was determined by placing it on a single crystal x-ray spectrometer. The beam of x-rays passed through an ionization chamber and then into the multiplier tube. The pulses from the tube were amplified further by a four-stage amplifier and were recorded by a scale of eight counting circuit. The efficiency of the tube was measured for radiation of wave-length 0.14 to 1.0A. From 0.5 to 1.0A the efficiency increased directly with the wave-length. At $\lambda=0.7$A about 400 photons were required for every pulse recorded.

26. Induction Electron Accelerator. DONALD W. KERST,* *University of Illinois*.—By using a magnetic field oscillating at 600 cycles and reaching a peak value of about 1600 gauss, it has been possible to trap electrons in somewhat circular orbits which miss the injection cathode. These electrons which are trapped in usable orbits are accelerated by the electric field induced by the increasing flux to an energy of about 2.35 Mev. During this acceleration axial and radial focusing are provided by the magnetic field which falls off approximately $1/r^{\frac{1}{2}}$. The increase in time of the flux enclosed within the orbit causes the oscillations which the focusing forces produce about ideal orbits to decrease in amplitude so that the electrons group themselves in a beam. During acceleration the orbit is held at a fixed radius of about 7.5 cm by fulfillment of the condition $\phi_r=2\pi r^2 H_r$, where ϕ_r is the flux enclosed within the orbit at a given instant and H_r is the field at the orbit at that same instant. Saturation of a portion of the magnetic circuit feeding flux through the center of the orbit causes destruction of this condition at $r=7.5$ cm after the electrons have been accelerated and the electrons spiral inward toward a target. The intensity of the x-radiation produced is somewhat in excess of the radiation from ten millicuries of radium.

* Now with General Electric Company.

27. Conjugate Potentials of a Grid Between Conducting Planes. DON KIRKHAM, *Utah State Agricultural College*.*—The function

$$W=-q\sum_{n=-\infty}^{\infty}\log\frac{\operatorname{vers}2\pi(z-2nhi)/a}{\operatorname{vers}2\pi(z-2di-2nhi)/a}-i(z-di)(V_c-V_c+4\pi qd/a)/h+V_a$$

yields the conjugate potentials appropriate to an infinite grating of equally spaced filaments situated between two infinite parallel conducting planes. The grating is distance d from the upper plane, and $(h-d)$ from the lower. The potential of the upper plane is V_a and of the lower V_c. The origin of rectangular coordinates is taken at the center of a filament with y directed upward. q is the charge density per unit length of filament. Transformations similar to the above may be used to obtain convenient solutions for a number of problems involving finite and infinite gratings. The relationship between an infinite product of versines and the quasi doubly-periodic (theta-) functions[1] has been obtained.

* To be read by title.

[1] Cf. L. Rosenhead and S. D. Daymond, Proc. Roy. Soc. **A161**, 382 (1937).

28. A Lattice Type Acoustic Filter. HAROLD K. SCHILLING, *Union College, Lincoln, Nebraska*.—Acoustic band elimination filters having a simple lattice structure have been developed. They consist of parallel grooved slats, the spaces between which function as transmission lines and the grooves as sidebranches. The grooves are parallel to the length of a slat and perpendicular to the direction of transmission. They are particularly suited to the filtration of the higher frequencies, say above 5 kilocycles. Attenuations of 40 to 70 decibels over wide bands are obtained easily. The parameters determining their characteristics are: the thickness and the width of a slat; the depth, width, distance between and number of grooves. Their effects may be understood in terms of the infinite filter theory of W. P. Mason,[1] and the finite filter theory by R. B. Lindsay.[2]

[1] W. P. Mason, Bell Tech. J. **6**, 258 (1927).
[2] R. B. Lindsay, J. App. Phys. **9**, 612 (1938).

29. Simultaneous Determination of Isothermal and Adiabatic Elasticities. H. F. LUDLOFF, *Cornell University*.—The dynamical methods for determining elastic constants,

in which the vibrations are excited by piezoelectric or magnetic means, can be used only over limited temperature ranges. Since the elastic properties are especially interesting at very high temperatures, a method of exciting the vibrations electrostatically has been devised, which allows removal of the temperature restriction. Moreover this method has the advantage of working in a range of several hundred to several thousand cycles per second and of so determining both the isothermal and adiabatic values of the parameter. Since the difference between both values increases greatly in phase transition regions, the above method is especially appropriate for measuring the steady transition between the adiabatic and the isothermal temperature curve of a parameter. In order to facilitate the best possible determination of the parameters, the relations between eigenvalues and elastic parameters are computed for the different vibrating systems which can be used in the set-up. In considering the heat-conduction and absorption processes in such systems one can determine the frequency ranges in which the vibrations are isothermal or adiabatic. The ranges are characterized by the properties and the dimensions of the sample.

30. Theoretical Stress-Strain Curve for Rubberlike Materials. HUBERT M. JAMES, *Purdue University*, AND EUGENE GUTH, *University of Notre Dame.*—A theoretical stress-strain curve has been derived for rubberlike materials built up from long-chain molecules connected into a network by cross bonds. This network extends throughout the material, and due to its thermal agitation exerts a pull on any bounding surface which must be balanced by external forces together with internal forces representable by an internal pressure in the quasifluid material. Treating the molecular chains as perfectly flexible and the bulk material as incompressible, one finds as the stress-strain relation for the model

$$F = KT[f(La) - L^{-3/2} f(L^{-1/2}a)].$$

Here F is the stress per unit initial cross section and L is the extended or compressed length divided by the original length. $f(x)$ is defined by

$$x = \frac{e^{2f}+1}{e^{2f}-1} - \frac{1}{f}.$$

K and a are constants characterizing the chain network, $1/a$ being the maximum value of L for the model. This stress-strain curve shows the observed downward curvature for small strains and a sharp upward curvature for larger strains. The latter effect is associated with the approach of the network to its maximum extension, and differs in its temperature dependence from the qualitatively similar effect due to the crystallization of rubber by stretching. The theory shows good agreement with observations on equilibrium stress-strain curves for rubber.

SATURDAY MORNING AT 10:00 O'CLOCK

Eckhart 133

31. Electrostatic Generator with Concentric Electrodes. R. G. HERB, C. M. TURNER, A. O. HANSON, AND N. D. CRANE, *University of Wisconsin.*—Our new electrostatic generator which was described in a recent letter to *The Physical Review*[1] will be described in more detail and further results on its performance will be discussed. The generator is now equipped with an electrostatic analyzer for measuring the energy of the ions. No difficulty has been experienced with the accelerating tube, either from leaks or from voltage breakdown. The ion beam is well focused, but is at present limited to a few microamperes. A discussion will be given of factors which limit the current and of possibilities for improvement.

[1] Phys. Rev. **58**, 579 (1940).

32. One-Tube Counter Quenching Circuit with Capacitative Feedback. T. N. GAUTIER, *University of North Carolina* (*Introduced by A. E. Ruark*).—The counter wire is connected to the control grid of the quenching tube (e.g., type 57) and the grid is connected through about 6 megohms to the grounded cathode. This resistance depends upon the counter employed. The counter cylinder is connected to the negative terminal of the counter voltage supply through about 2 megohms, and is coupled to the plate of the quenching tube through a capacitance (about 0.01 mf). Thus a positive quenching pulse is transmitted from the plate to the counter cylinder through the condenser. Alternatively, the cylinder may be connected to the grid, biased to cut-off, so that a negative pulse is applied to the counter wire. These circuits are fast and reliable. As compared with the Neher-Harper circuit, they have the advantage that the plate voltage of the quenching tube need not exceed the manufacturer's rating, and the counter voltage does not depend upon the grid bias voltage. As compared with the Neher-Pickering circuit, they have the advantage that the cathode of the quenching tube is at ground potential, obviating disturbances from the a.c. heater supply. Furthermore, the counter voltage supply does not have to furnish plate current.

33. Recurrence Pulses in Cosmic-Ray Intensity. A. H. COMPTON AND A. T. MONK, *University of Chicago.*—Daily mean cosmic-ray intensities, as given by the Carnegie Institution Model C cosmic-ray meter at Teoloyucan, Mexico, were reported* last year to show a recurrence tendency with an interval between 27 and 28 days, and with no diminution in the amplitudes of the four recurrence pulses studied. These pulses arise as follows. From each

calendar month are selected the five days for which the cosmic-ray intensity is highest. The intensities are then tabulated for the n days following (and preceding) these selected days. The average intensity (for the whole range of months available) corresponding to each n value is then plotted against n, and this curve has maxima lying between n's which are integral multiples of 27 and 28. These are the *positive* pulses. When the selected days are those for which the cosmic-ray intensity is *lowest*, a negative-pulse curve results. It has now been found that these pulses persist at least as far as the eighth, but with decreased amplitude. The analysis is being extended through the tenth pulse (both preceding and following).

* Monk and Compton, Rev. Mod. Phys. 11, 173 (1939).

34. The East-West Asymmetry of the Cosmic Radiation in High Latitudes and the Excess of Positive Mesotrons. THOMAS H. JOHNSON, *Bartol Research Foundation of the Franklin Institute.*—The slight east-west asymmetry in high latitudes, now confirmed by Seidl, is interpreted as resulting from deflections of the mesotron component in the earth's magnetic field after the rays have entered the atmosphere and have lost energy by ionization. Since this component contains about twenty percent more positive than negative rays the deflections produce an asymmetry. Orbits of rays in the range of energy where rest mass cannot be neglected have been investigated and the deflections determined. It is assumed that deflections without energy loss would have resulted in a symmetrical distribution for the ranges of energy concerned, and the asymmetry is traced to the difference between the actual deflection and that of a ray which loses no energy. In computing this difference, instead of the actual deflection, one avoids the necessity of introducing an upper boundary of the atmosphere. The deflection shifts the angular distribution so that rays which in the absence of a field would have produced an intensity proportional to $\cos^2 \zeta$ at zenith angle ζ actually produce this intensity at zenith angle $\zeta+\delta$, where the deflection δ is towards the west for positive rays and towards the east for negative rays. The asymmetries calculated in this way agree with the observed values and give the correct variation of the asymmetry with zenith angle and elevation. The theory is also in accord with what little is known of the effect of absorbing material upon the asymmetry. More extensive experimental studies of the asymmetry under various thicknesses of absorbing material would provide a method alternative to the magnetic cloud chamber for studying the positive excess at various energies.

35. The Exact Solution of the Integral Equations for Cosmic-Ray Showers. M. DRESDEN, W. T. SCOTT AND G. E. UHLENBECK, *University of Michigan.*—A fundamental problem of the theory of cosmic-ray showers is the determination of the average number of particles $F(E_0, E, x)dE$ in the energy range dE which will emerge when a particle of energy E_0 enters a layer of matter of thickness x. The theory connects the function F with the known probabilities of pair formation, bremsstrahlung and ionization by means of certain integro-differential equations. We have found an exact method of solution for these equations. The method starts with a Laplace transformation in x. Using the appropriate boundary condition the resulting inhomogeneous integro-differential equation in the variable E can always be transformed into an ordinary integral equation of the Fredholm type with variable lower limit. This can be solved by standard methods. A simplified model, proposed by Furry, will be used to illustrate the solution, and the connection with the existing approximation methods will be discussed.

36. The Variation of the Intensity of Extensive Cosmic-Ray Showers with Altitude. NORMAN HILBERRY, *University of Chicago and New York University.*—The intensity of extensive cosmic-ray showers has been measured at a number of altitudes from sea level to the top of Mt. Evans. A set of four Geiger-Müller tubes, each of 200 square centimeters effective area, was mounted just below the top of a Ford station wagon. Single counters were placed at the front and at the rear of the car and the other two were placed in vertical twofold arrangement at the center; the maximum extension between the extreme counters was 2.5 meters. The observed counting rates were:

COUNTS PER HOUR	ALTITUDE IN METERS
24.1 ±0.3	4330
20.5 ±0.5	3900
14.0 ±0.5	3240
7.3 ±0.8	2190
5.0 ±0.4	1616
1.47 ±0.15	95

The accidental counting rate was less than 0.2/hr. at 4330 m and less than 0.01/hr. at 95 m. Using a suitable power law energy distribution for the incoming particles, the cascade theory gives good agreement between the predicted variation and the experimental observations.

37. Production of Mesotrons by a Neutral Radiation. VICTOR H. REGENER, *University of Chicago,* AND BRUNO ROSSI, *Cornell University.*—An experiment was performed on Mt. Evans, Colorado (4300 m) to investigate the production of mesotrons by non-ionizing radiation. Mesotrons produced in 5 cm of lead were recorded by Geiger-Mueller counters in fourfold and fivefold coincidence arrangement. The fourfold coincidences could be operated by a single mesotron, whereas for a fivefold coincidence two or more mesotrons had to be generated in one process. By means of a counter tray above the producing layer of lead, operating in anticoincidence, only mesotrons produced by a non-ionizing radiation could be recorded. The absorption of the non-ionizing, mesotron-producing radiation was measured by placing additional layers of lead above the anticoincidence counters. Good evidence for the production of mesotrons was found. The number of mesotrons produced in 5 cm of lead (2/hr.) was about 1 percent of the total number of mesotrons entering the solid angle of the apparatus at that altitude. There is also evidence for the production of more than one mesotron in a single process. The non-ionizing, mesotron-producing radiation is not considerably absorbed by 2.5 cm of lead. This excludes photons as a producing agent and makes the production of mesotrons by neutrettos or neutrons probable.

38. A Study of the Production and Absorption of Mesotrons in the Substratosphere. GERHART GROETZINGER, E. O. WOLLAN AND MARCEL SCHEIN, *University of Chicago.*—In a coincidence-counter experiment carried out in an airplane at altitudes up to 9.3 km (22.9 cm Hg) an attempt was made to observe the production of mesotrons in an 8-cm lead block by some non-ionizing radiation other than photons. From our experiments it would seem that the number of mesotrons arising from such a creation is not greater than about 5 percent of the total number of mesotrons at this altitude. It appears further that photons are the main agent of the non-ionizing radiations which produce mesotrons at altitudes of 7 km. The experiment was also designed to give the absorption of mesotrons in lead of 19 cm and 27 cm thickness as a function of the altitude. Using these data and those obtained previously by Schein, Jesse and Wollan for 10 cm of lead, we have constructed an energy spectrum of the mesotrons at an altitude of 6.7 km. At this altitude about 35 percent of all the mesotrons have energies below 5.2×10^8 ev, while at sea level a very small fraction of the mesotrons have energies in this range. The experiment indicates also that neutrons with energies above 5×10^8 ev are not present in altitudes up to 9.3 km to an extent of more than about 4 percent of the number of mesotrons.

39. Wilson Cloud Chamber Study of the Scattering and Stopping of Mesotrons in Lead. R. P. SHUTT AND T. H. JOHNSON, *Bartol Research Foundation of the Franklin Institute.*—Seven thousand nine hundred stereoscopic photographs taken in a 24-inch cloud chamber have been used to study the stopping and scattering of mesotrons in lead. Above the chamber separated by fifteen cm of lead were two coincidence counters for controlling the expansions. Inside the chamber at 13-cm intervals were three lead plates 1 cm, 5 cm, and 1 cm thick, respectively. In the statistics given below only rays which had passed through the counters are included. Out of 4368 rays incident upon the upper surface and near the center of the 5-cm lead plate all but 78, or 1.8 percent, passed through it and were seen below. Similarly, in the lower 1-cm lead plate 31, or one percent out of a total of 3069 incident rays, were stopped. These values are in close agreement with those found from coincidence counter measurements under similar circumstances. Analysis of the scattering of mesotrons shows that 4.6 percent of the rays traversing 1 cm of lead and 15.2 percent of those traversing 5 cm of lead are scattered more than 3°. This fraction evidently increases with lead thickness, t, more rapidly than $t^{\frac{1}{2}}$, the dependency given by the theory of multiple coulomb scattering, and the discrepancy may indicate the presence of some large-angle nuclear scattering.

40. Cloud Chamber Pictures of Cosmic-Rays at 29,000-Ft. Altitude. G. HERZOG* AND W. H. BOSTICK, *University of Chicago.*—On December 20, 1939, a 6″ diameter cloud chamber in a magnetic field of 708 oersteds was carried to a height of 29,300 feet in a Douglas DC-3 transport airplane. The maximum measurable $H\rho$ was 5.6×10^5 which for an electron corresponds to an energy of 1.7×10^8 ev. Out of 155 photographs taken at altitudes greater than 15,000 feet 51 slow mesotron tracks and 30 proton tracks were identified. The number of slow mesotrons is 9 percent of the number of electrons and fast mesotrons. Some very dense tracks may be due to fragments of heavy nuclei. On April 30, 1940, another flight was made to an altitude of 29,300 feet. This time, in order to stop slow mesotrons a copper plate was put in the middle of the chamber. By their specific ionization, their radii of curvature, and the stopping power of the copper plate 7 particles stopping in the plate are identified as slow mesotrons. A total of 28 slow mesotrons was observed in the flight, giving an occurrence rate over 15,000 feet of 9 percent as compared with electrons and fast mesotrons. In only two cases is there evidence for the disintegration of a mesotron and this evidence is not conclusive.

* Now with the Texas Company, Houston, Texas.

SATURDAY MORNING AT 10:00 O'CLOCK

Ryerson 32

41. The Relative Abundance of the Stable Isotopes of Terrestrial and Meteoritic Iron. G. E. VALLEY AND H. H. ANDERSON, *Harvard University.*—Seven specimens of terrestrial iron obtained from various ores and widely different localities, and twelve meteoritic specimens from different types of meteorites have been examined. The type of mass spectrometer used produces a mono-energetic beam of ions by means of a precisely constructed source. This is then passed through a semicircular magnetic momentum analyzer. The emergent ion current intensity, as measured by a vacuum tube electrometer, is assumed to be proportional to the abundance of the isotope in question. The iron, after purification to remove Cr, Co and Ni, as well as Pd, Cd, and Sn, was electro-deposited upon platinum wire. Ions were produced by electron collision with iron vapor liberated by hot filaments of this combination. No new stable isotopes of iron were discovered. The average values for all the terrestrial specimens and for all the meteoritic specimens follow. They may be compared with the previously published values of de Gier and Zeeman[1] and of Nier.[2]

THE STABLE ISOTOPES OF IRON

Mass number	54	56	57	58
Terrestrial	6.37	100	2.37	0.34
Meteoritic	6.32	100	2.32	0.33
de Gier and Zeeman	7.2	100	3.1	0.55
Nier	6.6	100	2.3	0.31

The differences between our various specimens are on the order of a few percent and can be accounted for by instrumental effects. We conclude that the abundance of the stable isotopes of iron does not depend upon the place of origin of the specimen within the solar system.

[1] de Gier and Zeeman, Proc. K. Akad. Amst. **38**, 959 (1935).
[2] A. O. Nier, Phys. Rev. **55**, 1143 (1939).

42. The Relation Abundance of the Calcium Isotopes. C. W. SHERWIN AND A. J. DEMPSTER, *University of Chicago.*—The ratio of the abundance of the calcium isotopes at 40 and 48 has been measured under different conditions with a variety of sources. The total charges carried by the singly charged ions in a given time were compared electrically. With a spark between two calcium rods a ratio of 450 to 1 was found. Using an iron furnace to evaporate the calcium, and electrons from a hot cathode to produce the ions, 440 to 1 was observed. This is in approximate agreement with Nier's result (525 to 1)[1] obtained with this type of source. The same result was obtained by evaporating the calcium from an alloy of calcium and copper in a furnace. Just before the last had been evaporated a higher intensity at 48 was observed. Calcium reacts violently with gold, silver and copper to form an alloy. With a spark source where one electrode was one of these alloys, very abnormal intensities of Ca^{48} could be obtained. With a very narrow spark between a copper electrode and a silver calcium alloy, the relative abundance of Ca^{48} was 1 to 52, approximately ten times the normal intensity. We may explain the observation by supposing that the rate of combination of the calcium vapor with copper is greater for the isotope of mass 40 than for the one of mass 48.

[1] A. O. Nier, Phys. Rev. **53**, 282 (1938).

43. Explanation of the Periodic Deviations from the Schottky Line. CHARLES J. MULLIN AND EUGENE GUTH, *University of Notre Dame.*—The periodic deviations from the Schottky line observed by Phipps and his collaborators[1,2] and by Nottingham[3] in measuring the thermionic emission of electrons from tungsten and tantalum can be interpreted as being due to two partial reflections of the electron waves on the potential hill at the surface of the metal. These partial reflections give rise to interference and thus to a periodic term in the transmission coefficient for the escaping electrons. The transmission coefficient is obtained by using the functions of the parabolic cylinder to establish the connection between the asymptotic expansions of the wave function to the left and right of the top of the potential hill. The calculated positions of the maxima and minima of the deviations agree very well with the observed positions. In agreement with experiment, it is found that the positions of the maxima and minima are sensibly independent of the temperature; and that the dependence of the amplitude on temperature decreases as the applied field is increased. The calculated amplitude of the deviations increases with the field as does the observed amplitude. Both the amplitude and phase depend upon the work function of the emitting metal. No experimental data on this dependence are available, tungsten and tantalum having work functions which are very nearly equal.

[1] R. L. E. Seifert and T. E. Phipps, Phys. Rev. **56**, 652 (1939).
[2] D. Turnbull and T. E. Phipps, Phys. Rev. **56**, 663 (1939).
[3] W. B. Nottingham, Phys. Rev. **57**, 935 (1940).

44. The Exact Comparison of Small Currents. R. M. VANDERBERG, *University of Chicago* (*Introduced by A. J. Dempster*).—The two currents to be compared, approximately 10^{-12} amperes, are collected on electrodes connected to the intermediate cylinders of two triple condensers. The electrode systems are kept as near zero potential as possible by varying the potentials of the outer cylinders while the accuracy of these adjustments is tested by connecting an electrometer to one or the other of the inner cylinders at intervals. The ratio of the currents is given directly by the ratio of the compensating potentials set up on the outer cylinders, after correction for the difference of capacity between the outer and intermediate cylinders of the two condensers. The accuracy attainable was tested by inducing charges of a known ratio on the electrodes. A source of potential was connected to two condensers and by increasing the potential slowly, the induced charges provide two currents of constant ratio for testing purposes. It was found that ratios could be measured by the compensating method to an accuracy approaching one part in ten thousand. Charges set up when switch contacts are separated are the chief source of error.

45. Conduction of Electricity by Dielectric Liquids at High Field Strengths. HAROLD J. PLUMLEY, *University of Chicago* (*Introduced by A. J. Dempster*).—Certain liquid dielectrics, such as the pure paraffin hydrocarbons, which possess extremely low conductivities at moderate field strengths acquire some of the characteristics of semiconductors at field strengths in excess of 100,000 volts per cm. Thermionic emission, cold emission, collision ionization, and presence of ionizing impurities are the more important of the theories previously invoked to explain this effect. The results of our investigation of the dielectric properties of heptane at high field strengths tend to invalidate all four of these assumptions, although the last may not be definitely excluded at present. In the light of our experiments, which were conducted with very small electrode spacings in order to minimize the complicating effects of space charge and ionic recombination, it seems reasonable to suppose that the highly nonconducting dielectric liquids should be included as extreme cases in the general class of weak electrolytes. The presence of appreciable conductivity under high electric fields is ascribed to the lowering of the energy of the ionic bond by the applied field. This mechanism is supported by the results of experiments designed to show the effects on the conductivity of heptane of the following: work function of electrode, use of unsymmetrical electrode configurations, progressive purification and long time stress application, magnitude of applied field, and, finally, variation of electrode spacing.

46. The Recovery of Dielectric Strength in High Pressure A.C. Arcs. W. M. Bauer and J. D. Cobine, *Harvard Graduate School of Engineering.*—A direct oscillographic method has been employed in an investigation to determine the manner in which dielectric strength is recovered in short a.c. arcs after extinction. The results of this investigation extend the recovery curves to values of time so great that nearly complete recovery of dielectric strength is obtained. Observations cover a range of extinction time from 50 microseconds to 10 milliseconds; a pressure range from 1 to 32 atmospheres of nitrogen gas; and a current range from 0.25 ampere to 7.85 amperes. The current was supplied by a high potential transformer and was limited by reactance. An arc was obtained between graphite electrodes separated by a distance of 1 mm for the work at constant gap length. For comparison, a reignition characteristic is shown for an arc between copper electrodes. The results of these experiments show that for graphite electrodes the arc space recovers dielectric strength at a rate which decreases steadily with time, and that the sparking potential is approached asymptotically. For the copper arc, recovery is more rapid and reaches a knee in the curve after approximately 2 milliseconds, beyond which time there is practically no further increase in dielectric strength up to a time of 10 milliseconds.

47. Phase of Arc-Back in Rectifiers. Albert W. Hull and Frank R. Elder, *General Electric Company.*—Thyratrons of FG-41 type were tested at over-voltage for arc-back in a circuit which simulates operating conditions very closely. Memory oscillograms showed the time in the cycle at which the arc-backs occurred. At a mercury-control temperature of 40°C, the distribution was nearly random, with a maximum at the time of highest negative anode voltage, and depending in the same manner that the average arc-back rate was found to depend on voltage. When the mercury-control temperature was raised to 64°C, all the arc-backs occurred at the beginning of negative voltage application. The negative voltage was applied 10 degrees after commutation, and its shape was similar to that of an average rectifier circuit. These results are interpreted on the theory recently advanced by Kingdon and Lawton,[1] which attributes arc-back to charging up of small non-conducting particles on the surface of the anode. At low vapor pressure, where the ions remaining from the discharge have time to diffuse to the electrodes before negative voltage is applied, the charging is produced by field emission and hence depends on voltage. At higher pressure, diffusion is interfered with, so that ions are present when negative voltage is applied.

[1] K. H. Kingdon and E. J. Lawton, Gen. Elec. Rev. **42**, 474 (1939).

48. The Stability of a Low Pressure Mercury Arc. Paul L. Copeland, *Illinois Institute of Technology,* and W. H. Sparing, *Westinghouse Electric and Manufacturing Company.*—The stability of a low pressure arc increases rapidly as the arc current is increased, and there is no critical current which separates stable from unstable operation. In these experiments the mean life of a mercury arc operating under a carefully controlled set of conditions was determined by a statistical analysis of a hundred or more observed lives. The dependence of mean life upon both arc current and vapor pressure was investigated. The stability of the arc increased as the vapor pressure was raised from 0.001 to 0.004 mm Hg. In the first observations the cathode spot was free; later observations were made with the spot anchored. The marked increase of stability when the spot is anchored, observed by Tonks,[1] was studied. The results suggest that in either case the mean life rises exponentially with the arc current in the ranges used. For the arc operating at 0.0012 mm Hg pressure with a free cathode spot, the mean life T_m (seconds) may be computed from $T_m = 0.00343 \exp(2.427\, I)$ where I is the arc current in amperes. At the same pressure with the spot anchored, the mean life may be represented by $T_m = 0.000935 \exp(19.92\, I)$.

[1] L. Tonks, Physics **6**, 294 (1935).

49. Photoelectric Sensitization of Metal Surfaces in Group II by Optical Dissociation of Water Vapor. J. T. Tykociner and L. R. Bloom, *University of Illinois.*—Photo-cells made by evaporation on glass of Ca, Sr, Ba, Be, Mg, Zn and Cd and supplied with quartz windows were subjected to the irradiation from a quartz mercury arc ultraviolet source, the cathode being kept at a voltage below ionization potential while water vapor at very low pressures was introduced into the cell. In each case it was found that the sensitivity in vacuum of the surfaces increased with the time of exposure until maximum was reached. No increase was observed with the cell either in darkness or with the applied voltage reduced to zero. Precautions were taken to keep out all traces of mercury, to make certain that the effect was due to a direct ionization of H_2O vapor. The time necessary to reach the maximum of sensitivity was found to depend on the H_2O vapor pressure and on the intensity of the ultraviolet source. The effect of higher pressures was to reduce gradually the sensitivity after maximum was reached. The maximum sensitivities obtained by this method varied for each metal. The greatest increase, about fifty times that of the pure untreated surface, was obtained with a Be surface. The smallest effect was noted with a Cd surface. A bulletin with details will be published by the University of Illinois Experiment Station.

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